



# **Implications of Cooperative Adaptive Cruise Control for the Traffic Flow**

## **A Simulation Based Analysis**

Axel Wolfermann, Stephan Müller

# German Aerospace Center (DLR) at a Glance

- 5.100 employees working in 27 research institutes and facilities
  - at 8 sites
  - in 7 field offices.
- Offices in Brussels, Paris and Washington

## Program Directorates

- Aeronautics
- Space
- Transport
- Energy





## Research at the DLR Institute of Transport Research

- analysis of the **Transport Demand** in private and commercial transport
- **Model-Based Analysis** of the impacts of technical, organisational and political transport related measures
- development and assessment of **Future Scenarios**





# Agenda

## Motivation

## Introduction

Cooperative Adaptive Cruise Control (CACC)

## Methodology

Simulation based assessment

## Results

Impact of CACC on Traffic Flow

## Discussion





# Motivation

Goods Transport on the road is attractive...  
...when the roads are not congested

## Capacity improvements

### Infrastructure

- new lanes

### Vehicles

- eg. Gigaliner

### Traffic Management

- Avoid traffic
- Shift traffic
  - Modal shift, shift in time, shift in space
- Control traffic
  - eg. ITS → eg. CACC







Source: ATZonline



Source: Promote Chauffeur

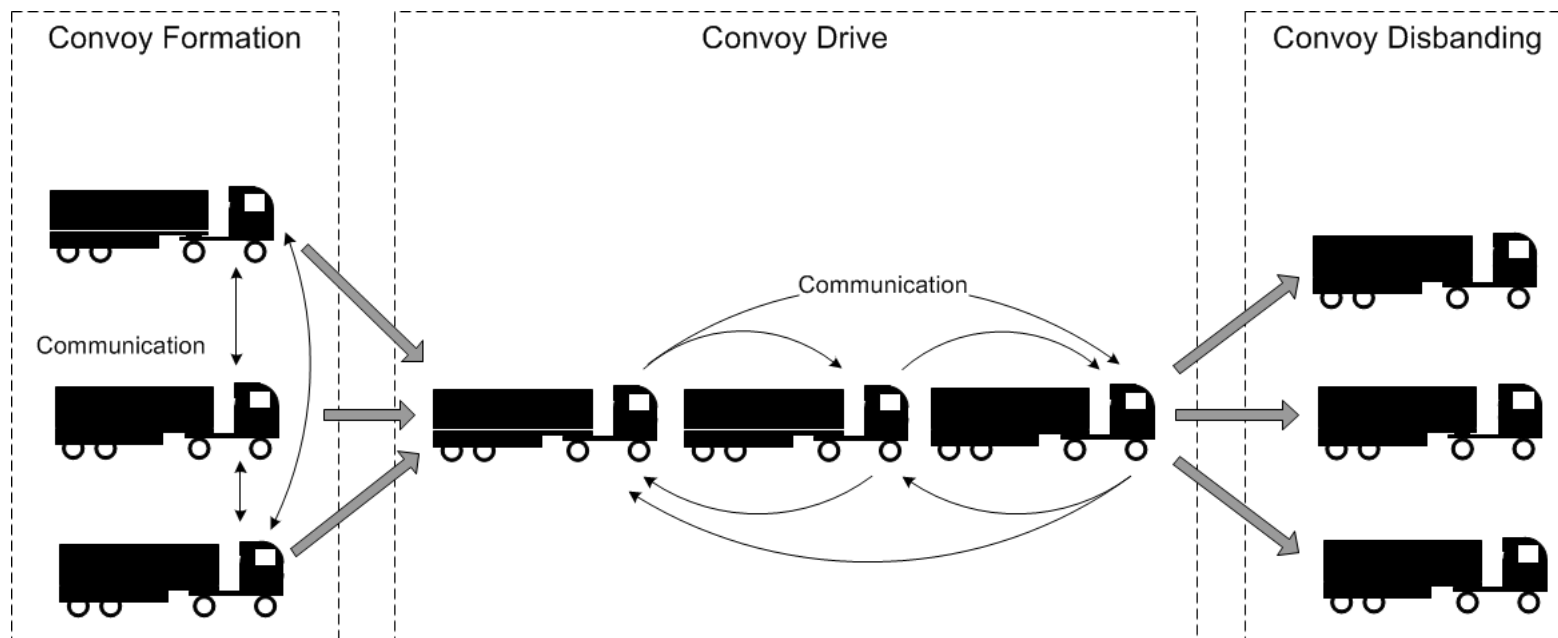


Source: Promote Chauffeur

## Cooperation Adaptive Cruise Control (CACC)

# Generell Mode of Operation of CACC

- Trucks driving connected in a platoon
- Leading vehicle is driven manually, followers are steered fully automated
- Up to 7 vehicles can be coupled





## Research on CACC

### ➤ USA

- California PATH

### ➤ Europe

- PROMOTE CHAUFFEUR I/II 1996-2003
  - Demonstration of Technical Feasibility
- SARTRE (Safe Road Trains for Environment) 2009-2012

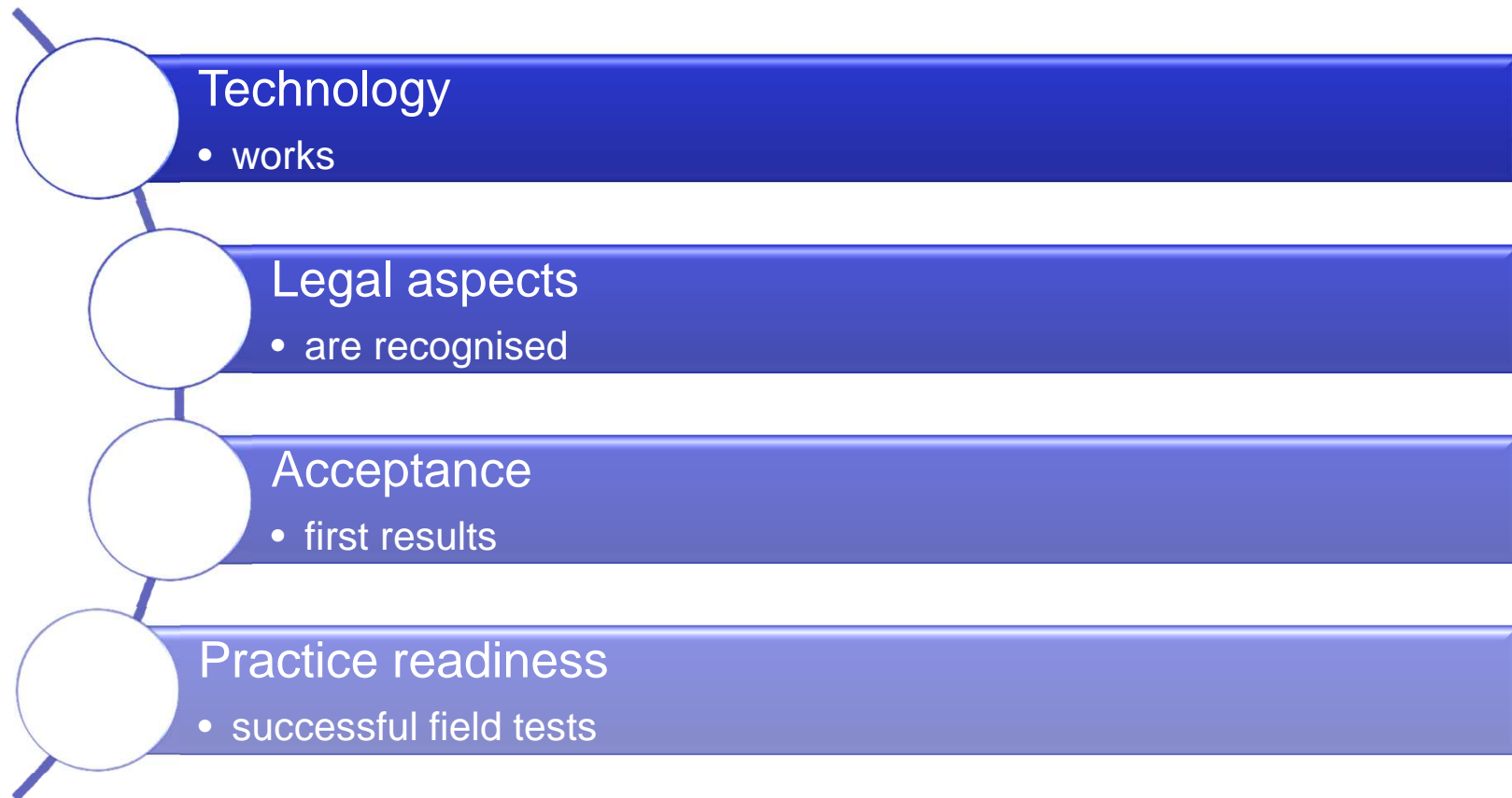
### ➤ Germany

- EFAS (Szenarios of Deployment of Driver Assistance Systems in Goods Traffic) 2001-2002
- MFG (Preparing Measures for practical Deployment of Driver Assistance Systems in Goods Traffic) 2003-2004
- KONVOI 2005-2008
  - field tests in real traffic flow

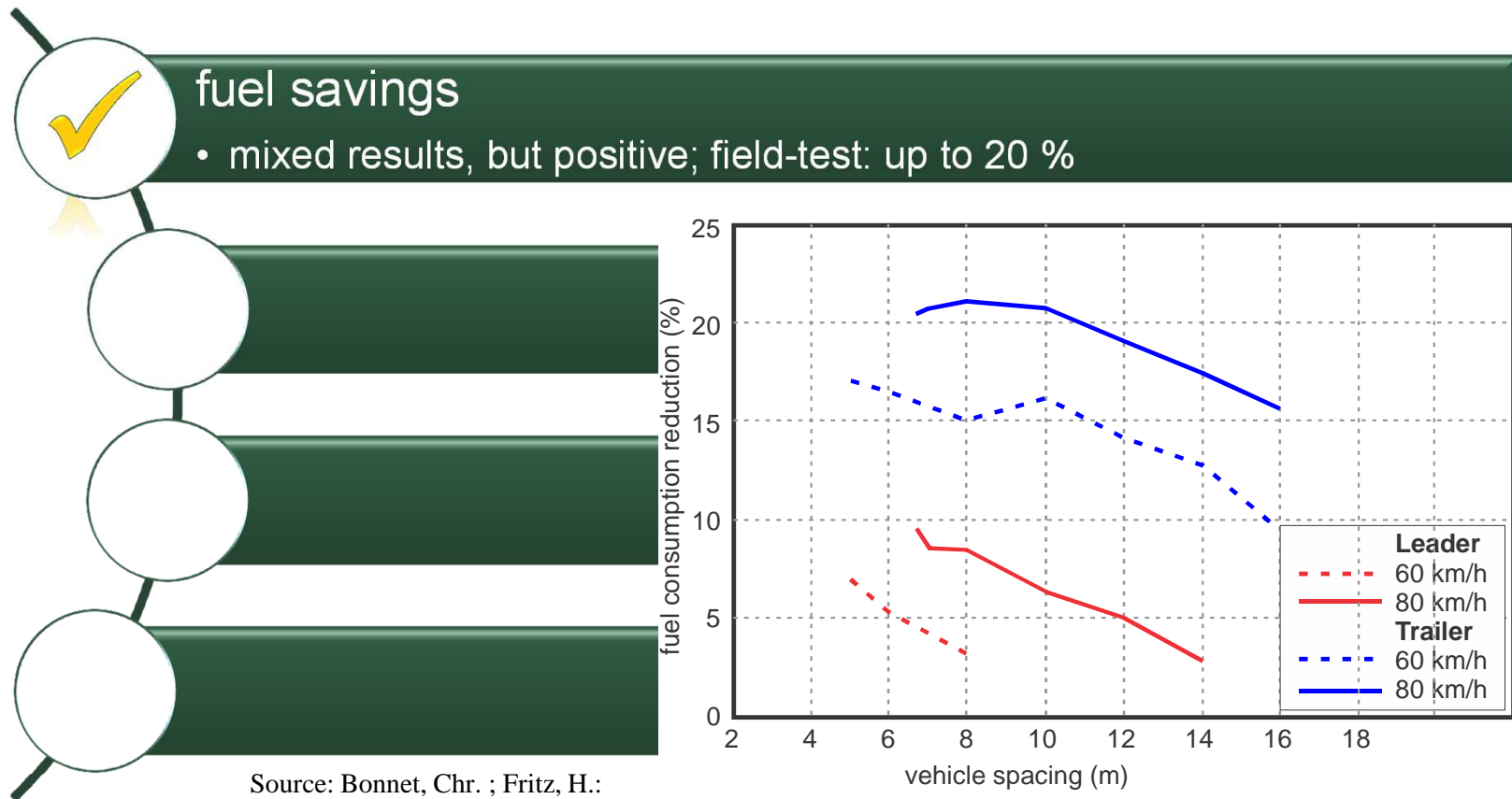




## Research on CACC – Viability



# Research on CACC – Impacts



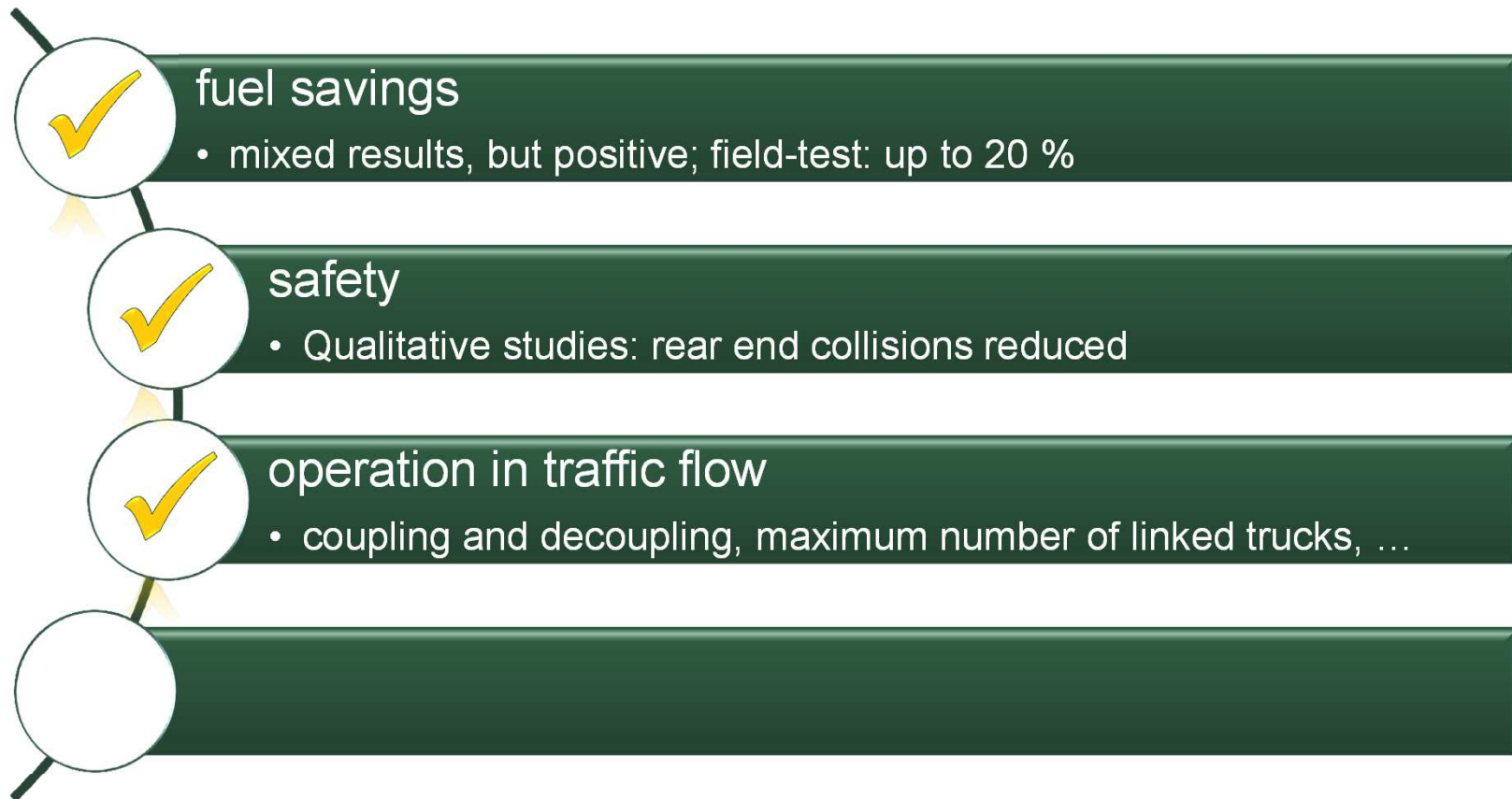
Source: Bonnet, Chr. ; Fritz, H.:

Fuel Consumption Reduction Experienced by Two PROMOTE-CHAUFFEUR Trucks in Electronic Towbar Operation.

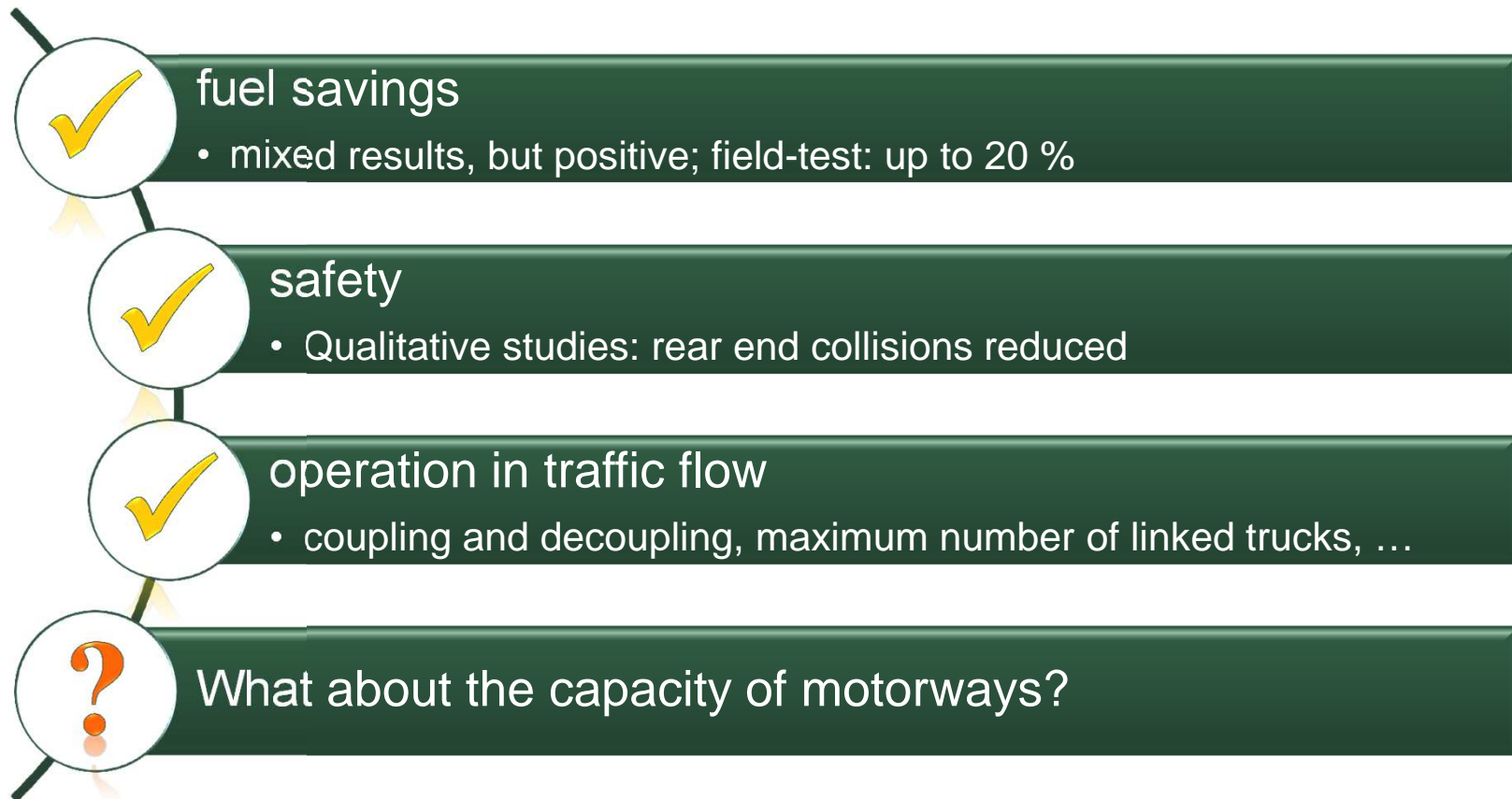
In: 7th World Congress Conference on ITS, 2000



## Research on CACC – Impacts



## Research on CACC – Impacts





# Impact of CACC on the capacity

## **Methodology**





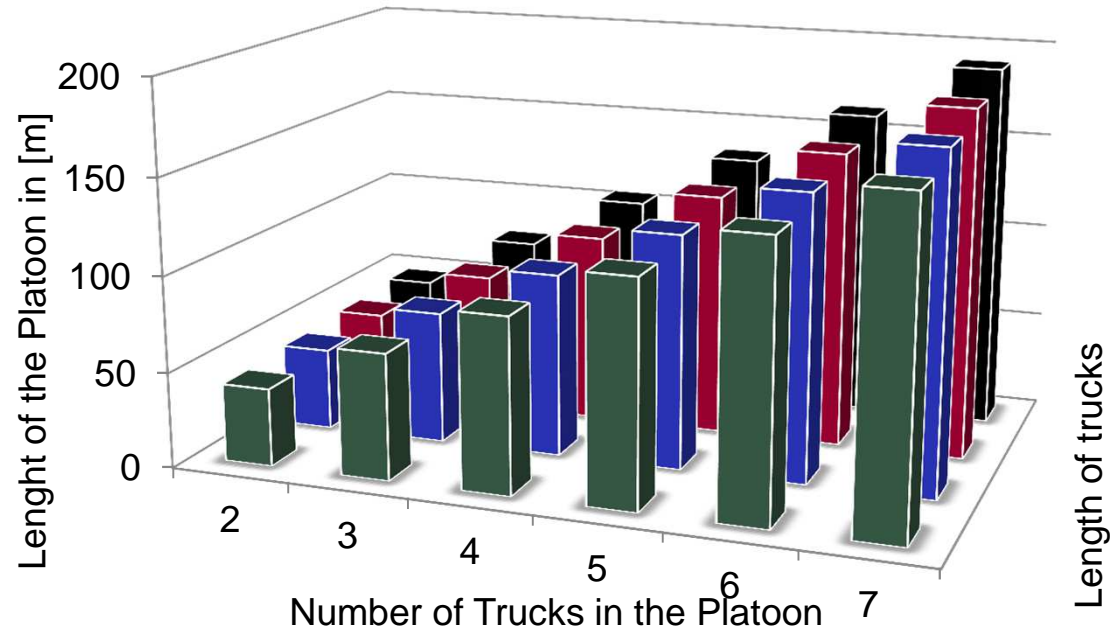
# Outline

- **Question:**  
Impact of linked road trains on the capacity in relation to penetration rate, number of trucks etc.?
- **Microscopic traffic flow simulation (VISSIM)**  
without and with equipped trucks
- **Szenarios**
  - motorway, no intersections, three lanes, one-way, slope of 1 %
  - varying...
    - traffic volume
    - number of trucks
    - share of CACC-equipped trucks

## Special View on implemented CACC-Trucks

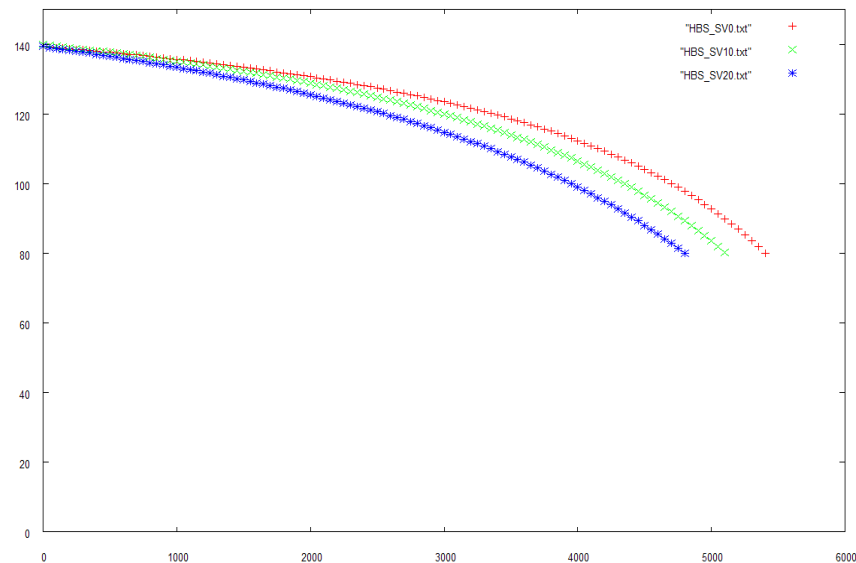
- Length distribution of trucks **based on real data**
- Only Trailer-Trucks and Drawbar Combination Trucks are equipped (~80 % of all trucks on motorway)
- Number of trucks in platoon uniformly distributed

- A very long truck simulates the platoon
- Distance between vehicles  
 **$dx = 10m$**

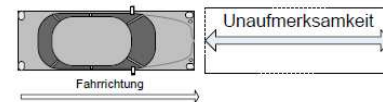


# Calibration of VISSIM

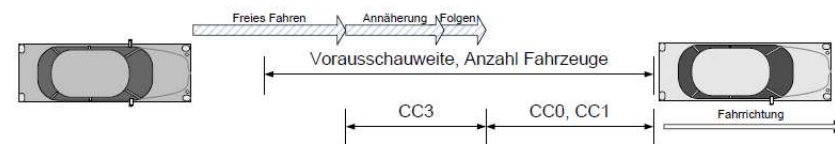
- Fitting of q-v-curves (no trucks, 20 % trucks, 10 % trucks)
- benchmark: HBS (German HCM)
- subsequent model tuning by driver behavior (many parameters)



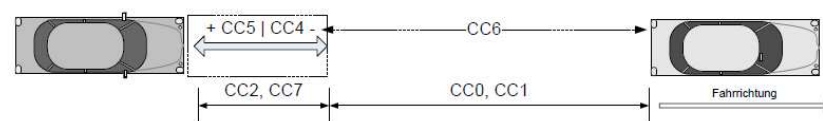
## Parameter of free riding



## Parameter of approximation

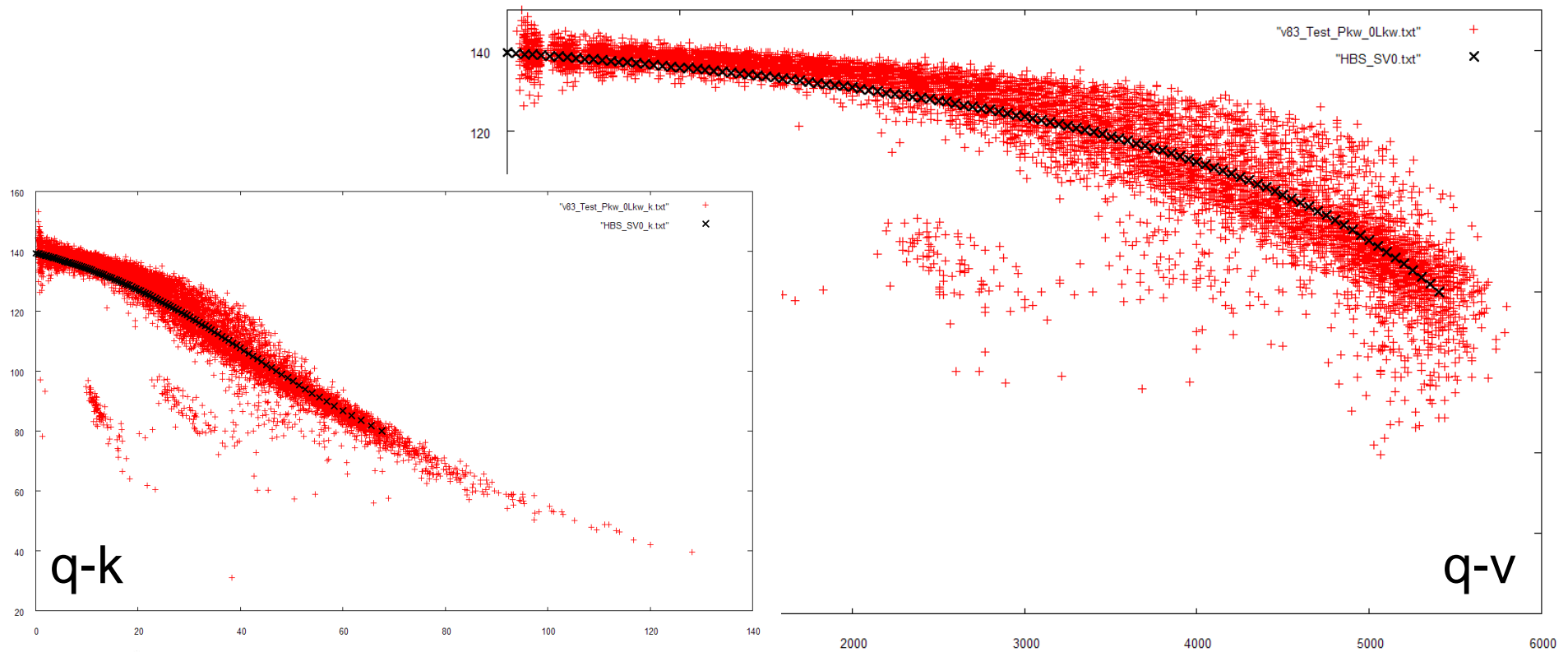


## Parameter of following



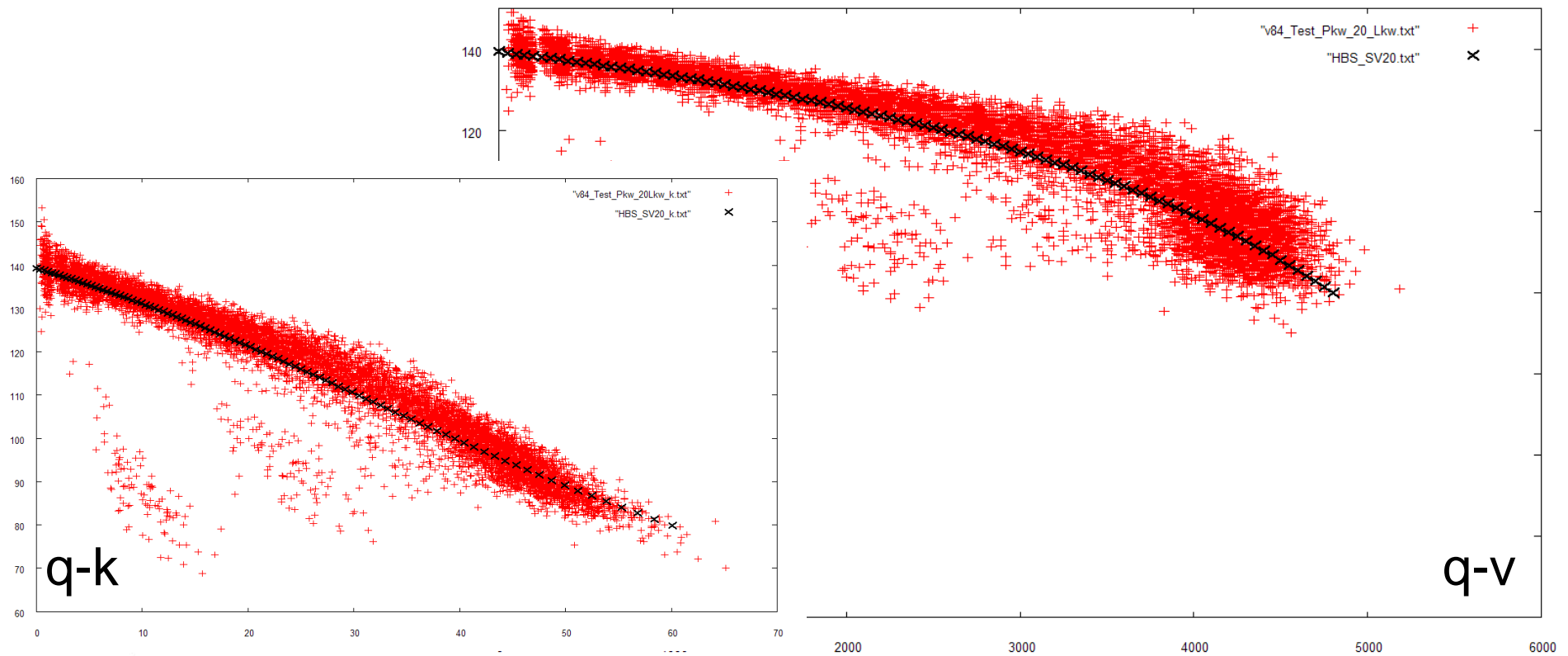


## Calibration Process: No trucks





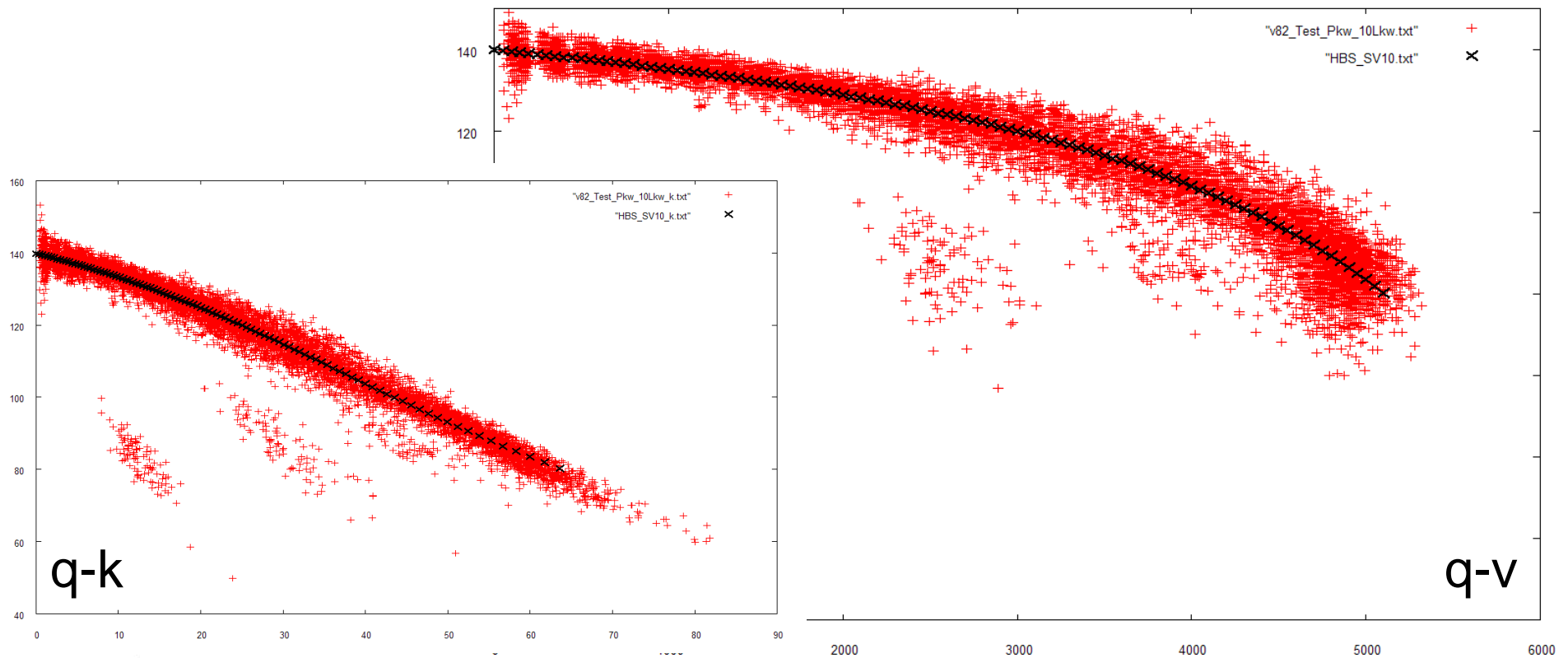
## Calibration Process: 20% trucks







## Calibration Process: 10 % trucks for validation





# Impact of CACC on the capacity

## **Results**

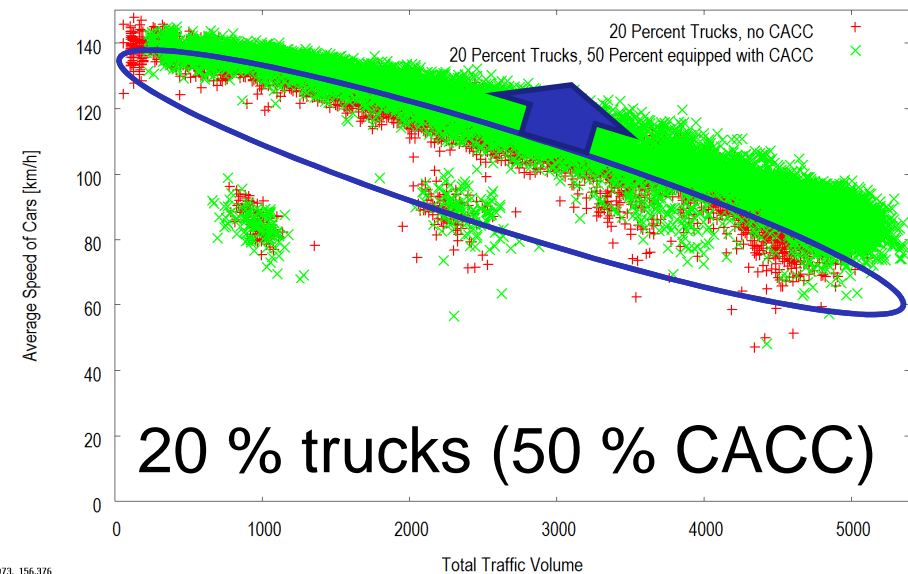
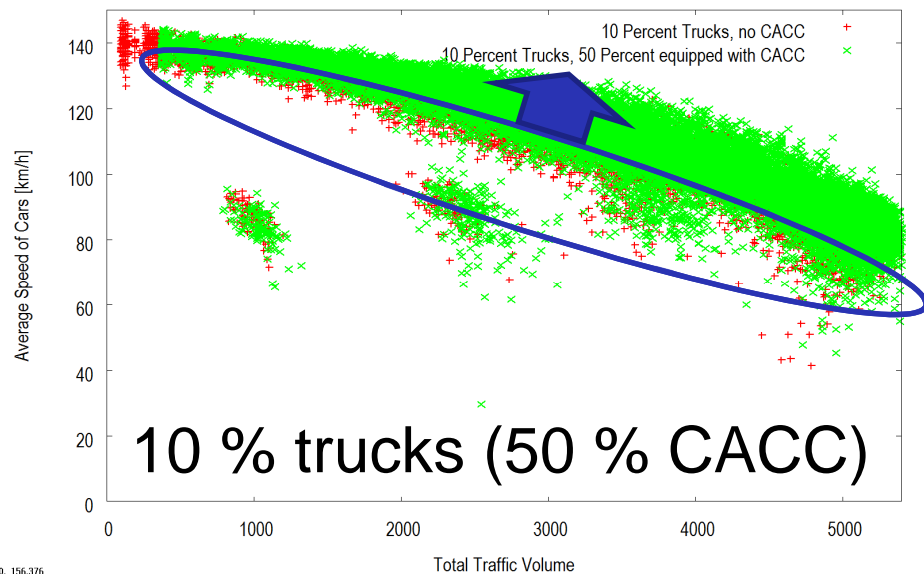




## Results of the simulation

➤ Effects on Traffic Flow with 50 % CACC-equipped Trucks

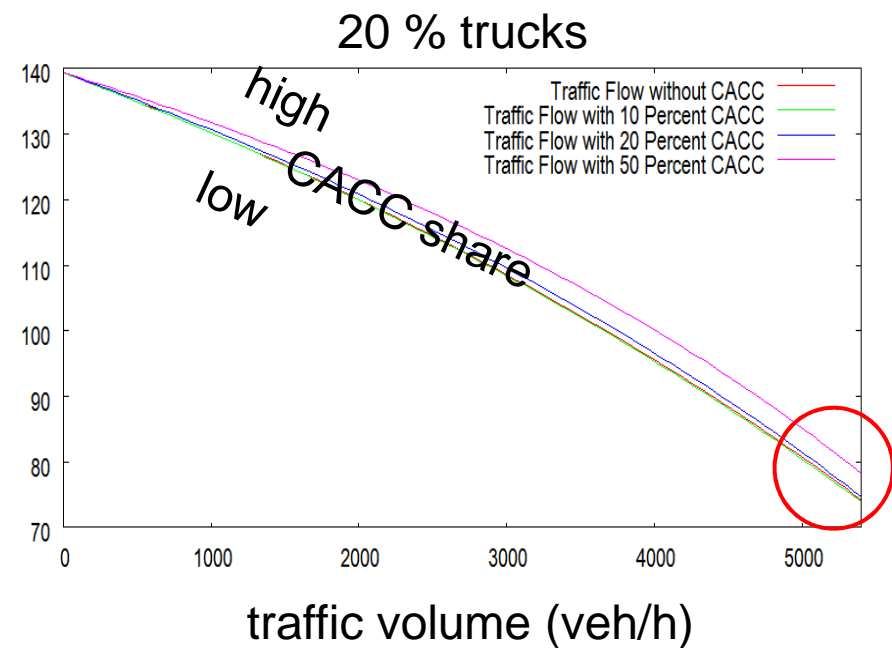
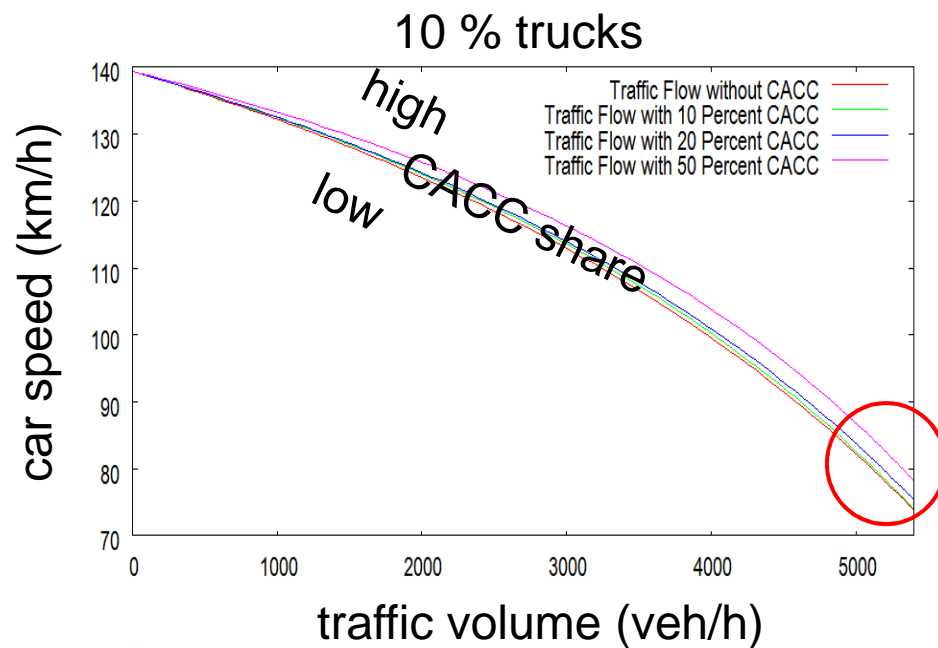
➡ *CACC has a significant effect on traffic flow*





## Results in Detail

- up to 6 % higher capacity  
(traffic volume at breakdown speed)
- insignificant effects for low penetration rate





# Discussion



**Deutsches Zentrum  
für Luft- und Raumfahrt e.V.**  
in der Helmholtz-Gemeinschaft

Slide 23

Implications of CACC on Traffic Flow :-> Müller, Wolfermann > 4th ECITL Thessaloniki >13th October 2011





## Conclusion

- Positive **impact on capacity** quantified  
(~5 % for 50 % penetration rate)  
based on realistic vehicle mix
- **high penetration rate** of CACC required  
for significant overall impact on capacity
- To the positive effects of CACC
  - Fuel Saving
  - Safetywe can add
  - **Capacity**



## Outlook

- quantitative results can be used to calibrate (macroscopic) models
- effect of coupling and decoupling yet to be incorporated
- extension to different vehicle types (passenger cars) possible



Thank You Very Much For Your Attention!

Dipl.-Ing. Stephan Müller  
Dr.-Ing. Axel Wolfermann

German Aerospace Center (DLR)  
[stephan.mueller@dlr.de](mailto:stephan.mueller@dlr.de)  
[axel.wolfermann@dlr.de](mailto:axel.wolfermann@dlr.de)